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Improving Infrastructure Towards Traffic Accident Prevention: Roundabout Using Expanded Polystyrene in Loose Soil

Tomas Exequiel Diaz Miret [#1], Joaquin Franco [*2]

[#] *Parana Regional School of Engineering, National Technology University*

1033 Almafuerte Avenue, Paraná, Argentina.

[1] tomazdiazmiret@alu.frp.utn.edu.ar

[2] joaquinfranco@alu.frp.utn.edu.ar

***Abstract*— This paper addresses the safety and traffic accident prevention in a neighbourhood located by a national route in Oro Verde, Entre Ríos, Argentina. Its entry and exit are dangerous for the citizens living there because of its heavy traffic. As this area has loose soil, the solution analyzed in this paper is the design of a roundabout using Expanded Polysterene. This type of infrastructure may be efficient considering the needs of the neighbours and the structure stability of the route.**

***Resumen*— Este trabajo aborda la seguridad y prevención de accidentes de tránsito en un barrio ubicado a la vera de una ruta nacional en Oro Verde, Entre Ríos, Argentina. Su entrada y salida son peligrosas para los ciudadanos que viven allí debido al intenso tráfico en el lugar. Como esta área tiene un tipo de tierra inestable para las construcciones, la solución analizada en este trabajo es el diseño de una rotonda construida con poliestireno expandido. Este tipo de infraestructura puede resultar eficiente considerando las necesidades de los vecinos y la estabilidad estructural de la ruta.**

I. Introduction

As urbanization in the world has increased, it has had an impact on the environment as well as on people's safety, among other aspects which are important for the Civil Engineering field. The process of urbanization is especially dangerous in neighbourhoods that are close to national routes in Argentina. There are some factors that worsen the risks in these areas. Those factors are structural – such as the outdated designs and the lack of maintenance of the entries to the neighbourhoods – as well as social – such as a reckless attitude on the part of the drivers.

In this sense, it is evident that there is a need to improve the existing infrastructure of urbanized areas that are close to national routes in order to guarantee accident prevention. However, these improvements should follow sustainable requirements. As stated in the National Academy of Engineering (NAE) Challenges report, it is essential to "restore and improve urban infrastructure" [1] in order to guarantee people's safety in a sustainable way.

The sustainable improvements that can be made in neighbourhood entries by national routes are many. Among these, the design of a roundabout can limit the speed to prevent accidents. As well as this, the analysis of the type of soil is also important to use construction materials that are in accordance with the soil, to therefore avoid car skidding or other problems to drive the vehicles safely. In this paper, the improvement that will be addressed as a possible improvement to a neighbourhood in Oro Verde, near Parana, Entre Rios, Argentina is related to both changes mentioned above. This area presents loose type soil and cars pass by at a very high speed. Because of this, the improvements suggested imply designing a roundabout using the Expanded Polystyrene (EPS) method.

The aim of this paper is to analyse the feasibility of the construction of a roundabout using the EPS method in an area with loose-type soil. To achieve this purpose, this paper has been organized as follows. First, the location and description about Oro Verde will be explained. Second, the characteristics of a roundabout on a route will be presented. Third, the description of the EPS method as well as its features will be mentioned and the reason why EPS has been chosen for this soil type. Fourth, this paper will mention some examples where EPS has been used in similar areas.

II. Oro Verde Location and Characteristics

In the first place, the section presents the area where the implementation of an EPS roundabout will be analysed. Oro Verde is a village that is five kilometers away from the south entry of Parana, which is the capital of Entre Rios. Nowadays, Oro Verde has grown notably in the last years because it used to be a university village and now it has grown in terms of its number of inhabitants and infrastructure as a city, thus moving away from its former agricultural nature [2].

This south entry is the only one that connects to Parana and it has a high flow of traffic because many people from Oro Verde and its surroundings commute to Parana to work and do other activities. In spite of the fact that a part of the Paraná-Oro Verde route has been improved, other parts of the Route 11 has not been upgraded. For this reason, the entry to the neighbourhood called Lomas de Oro Verde, which is located on Route 11-Km. 12, is still dangerous for its inhabitants.

The entry and exit to Lomas de Oro Verde are outdated because the neighbourhood was not designed for the current urbanization of the area. They are very dangerous because it does not have good visibility, location, and other factors of the route. Currently it is necessary to improve this situation to guarantee people's safety, but the solution to this is constrained by the loose-type soil of the area. The problem

of the soil is that it has clay, which makes it an expansive soil when it is wet or compresses when it is dry. This depends on the climatic conditions. As stated in [3], "(e)xpansive soils give major challenges to geotechnical engineers because of high swelling and shrinkage characteristics" (p.331). For this reason, the use of Expanded Polystyrene (EPS) may offer a solution to the design of a roundabout in the entry to Lomas de Oro Verde neighbourhood.

III. CHARACTERISTICS OF ROUNDABOUTS ON THE ROUTE

In this section, this paper will refer to the most important characteristics of roundabouts and the reason why they are a good option for this neighbourhood in Entre Ríos to solve the traffic problems and reduce accidents on the route.

A roundabout is defined as "an intersection that has a central island that is unidirectional, and the cars drive around the central island" [4, p.122]. In modern roundabouts, the drivers can check on all inlets when they are in the roundabout. Another feature is that the cars hold the movement around the central island and reduce vehicle speed [4]. These features of the roundabouts are important because they produce some benefits to the area and to the drivers that use the infrastructure.

A roundabout offers the following advantages. First, the roundabouts have a positive influence on the environment because the cars do not stop at traffic lights; thus, the cars reduce fuel consumption because do not stop and accelerate. Second, the reduction of vehicle speed slows down the traffic which, in turn, has a positive effect on safety. Third, the central island produces good visibility for pedestrians and cyclists. It is also used to improve the aesthetic of the route with monuments or greenery. The benefit that is the most important one for this paper is the following. The safety of entry roads is key because the drivers use the roundabout to enter neighbourhoods or select the route that they need. This allows the drivers who want to enter and exit neighbourhoods to do so under safe conditions since car drivers on the route should slow down the pace at the roundabout.

The best roundabout for this neighbourhood is the single lane roundabout. The characteristics that this type of roundabout presents are necessary for the Lomas de Oro Verde neighbourhood situation. First, it is less expensive than other types of roundabouts. Second, it is a roundabout that does not need too much area for its infrastructure. Despite the high traffic on this area, a big roundabout would not be suitable for this neighbourhood. Therefore, a single-lane roundabout will meet the need of the neighbours by decreasing the cars speed.

IV. EPS METHOD AND FEATURES

This part of the paper will describe the possible solution to the construction of a roundabout in an area with loose-type soil, as it was mentioned before. The problem is difficult to solve in simple terms and it requires to use a method that is not widely used for applications on routes in Argentina. This method is Expanded Polystyrene, which has been used since 1950s [5]. EPS is used for different applications but the important one for this paper is the reduction of settlement below embankments.

The EPS "is a plastic/polymeric material with a chemical composition of C8H8". It is a lightweight material and this is related to its density. [5, p.4]. The density is an important factor for EPS because the manufacturing costs as well as mechanical and non-mechanical properties depend on this. In the case of the use of EPS on roads, the density used ranges between 11 and 30 kg/m3. According to [5, p.7], "with its lightweight property, geofoam blocks can be easily handled after manufacturing, during curing, transportation or placement in the field. Two workers can handle a 0.6m x 1.2m x 2.4 m half size block of an average weight of 35 kg for 20 kg/m3 density EPS geofoam."

There are many advantages of the use of EPS. As for the environmental advantages, EPS is a recyclable material and it does not contaminate the ground and ground water because this is a non-biodegradable and chemically inert material and it has a normal life cycle of 100 years. [5]. A further advantage, from the structural point of view, is that it helps the filling to maintain the structure and form of the route. In this sense, EPS addresses the problem that the area presents to carry out a roundabout.

V. EXAMPLES OF THE USE OF EPS

In relation to the last section, EPS is a great solution, which is widely used in the world. As it is a versatile material, it can be used in different types of soils and for a variety of building projects. For this reason, EPS has been used in many infrastructures such as houses, routes, bridges, among others.

For the purposes of this paper, two buildings where EPS has been used will be mentioned. These constructions were carried out in similar conditions as the ones that the Lomas de Oro Verde neighbourhood presents. The first example is a road embankment in Passoo del Brattello, in Parma, Italy, characterized by its unstable slopes and the second are the works along the Grande Raccordo Anulare of Rome, a motorway with the permanent static loads.

As mentioned above, EPS has been used on the Passoo del Brattello, which is a road infrastructure in Italia. The building had high volumes of soil movement so 34 layers of EPS were used as filling to the embankment of the route. Although the high amount of EPS used is important to highlight, there is another aspect that characterized the used of EPS on this building project. This infrastructure is an important example because it was built in an extremely difficult area in terms of accessibility difficulties for the workers and machines. This problem was overcome thanks to the characteristics of EPS previously analyzed in this paper [6]. The use of EPS in this road project is illustrated in Fig. 1.

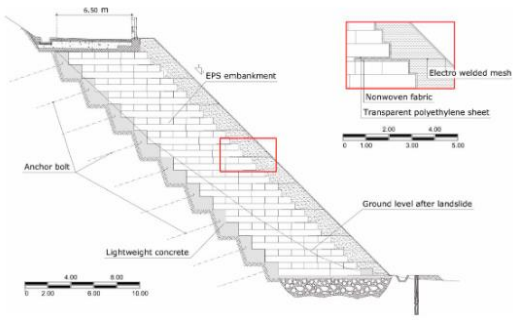

Fig. 1. EPS used in Pasoo del Brattello, Parma [6]

EPS has also been used in the Italian works of ANAS (National Autonomous Roads Corporation) in two forms to build the three-lane of the North-West quadrant of the motorway called Grande Raccordo Anulare of Rome. EPS was used as a light filling and as a road embankment material. For the lightweight over-filling of a cut-and-cover artificial tunnel, 14,000m3 of EPS 25 have been used, having about 10 m tall. This project shows that the EPS can be used for a roundabout filling [7].

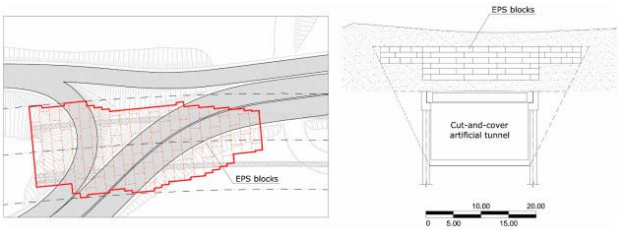

Fig. 2. EPS used in Grande Raccordo Anulare of Rome [6]

These examples represent some characteristics that EPS has in buildings, which are needed in Lomas de Oro Verde to the construction. Also, there are many types of uses to EPS in the world. It has been widely used because of its lightweight and versatility, which help project designers and workers to carry out a project in a more convenient way.

VI. Conclusion

After analyzing the use of EPS to build a roundabout in the entry to the Lomas de Oro Verde neighbourhood, it can be concluded that this is project is feasible to be carried out in this neighbourhood. A single-lane roundabout would improve the infrastructure of this neighbourhood towards traffic accident prevention. A roundabout using EPS in this area with loose soil would help achieve the NAE challenge by improving infrastructure in a sustainable way, thus producing a benefit to the environment.

Tomas Exequiel Diaz Miret is a Civil Engineering student at UTN FRP: tomazdiazmiret@alu.frp.utn.edu.ar. Joaquin Franco is a Civil Engineering student at UTN FRP: joaquinfranco@alu.frp.utn.edu.ar.

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